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By W. H. Jordan and P. R. Bell

Linear amplifiers are used so generally in nuclear physics research that a laboratory of any size will require many such instruments. While the requirements may be different for each experiment, a good amplifier can be adapted to most of them. An attempt has been made to design a reliable general purpose amplifier that can be built in some quantity and will yet perform uniformly. It is sufficiently flexible that it can be used for most experiments involving proportional counters, electron collection in ionization chambers, and particle counting with secondary electron multipliers. Nothing basically new or original is claimed for this amplifier, but it is believed that the general design and layout is a step forward and will be of general interest. A great deal of the electrical design on the video amplifier section was taken from the Model 500 amplifier developed by Sands and Elmore at Los Alamos.[1]

The main amplifier is divided into three parts, the video amplifier, the pulse height selector, and the power supply. (The preamplifier will be discussed later.) It is designed to receive signals from and supply power to the preamplifier through the connector J_1 (Figure 1). The signals are differentiated by the network C_3 (or C_1, or C_2) and the associated series resistors, giving time constants of approximately 0.2, 2, and 20 μsec, respectively. Since the time constant of this circuit is many times shorter than any other coupling time constant in the amplifier, the output pulse is essentially free from overshoot. Some such differentiating circuit is necessary in linear amplifiers to produce good signal to noise ratio. The advantages of making its time constant quite short are the following:

(1) The amplifier recovers quickly from a pulse, thus permitting high counting rates.

(2) A much larger β-ray background can be tolerated when counting α-particles, or similarly a large α-ray background will not "pile up" to give pulses as large as fission pulses.

(3) Troubles with microphonics and hum are greatly reduced.

The video amplifier consists of two cascaded sections and a cathode follower output tube. Each section has two gain stages and a cathode follower. Degenerative feedback is used from cathode to cathode to stabilize the gain, the feedback ratio being about 30. The high frequency cutoff of the first section can be varied by means of the selector switch S1B, which is ganged to the differentiation switch S1A. As the bandwidth is decreased the gain is increased by changing the feedback resistor so the noise at the output terminal of the amplifier remains approximately constant. In the wide band position the gain of each section is 100.

Either a high or a low output impedance can be selected by switch S4. The high impedance connection is intended for direct deflection of an oscilloscope when maximum speed of response is not

[1] Private communication.

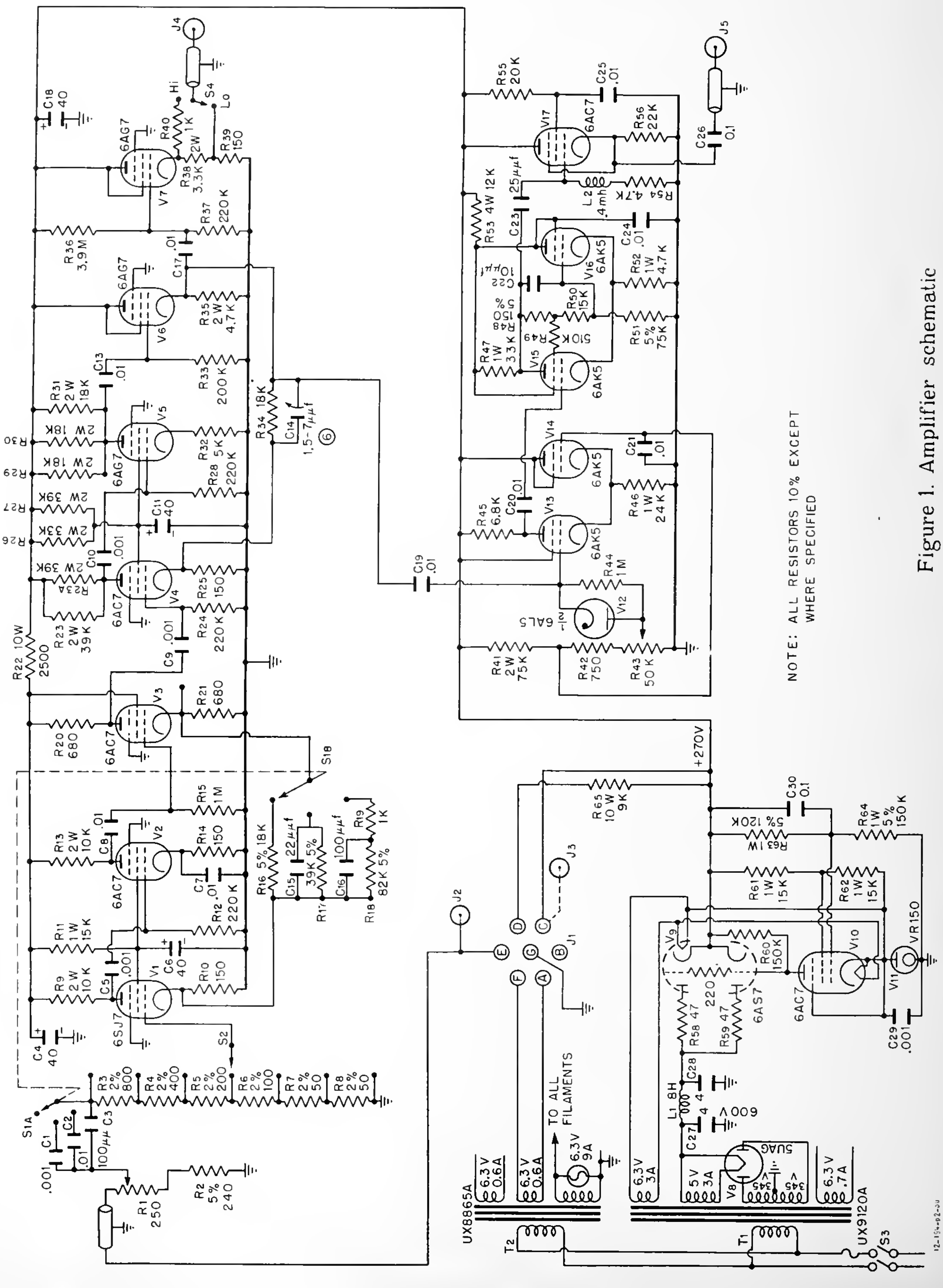

Figure 1. Amplifier schematic

required. A positive signal of 100 volts may be obtained. For very fast counting or accurate coincidence measurements the low impedance position should be used, a signal of 5 volts being available. Although the amplifier is designed to produce positive pulses only, either sign of input signal can be used by connecting the input of V4 to the plate or cathode of V3.

The pulse height selector is designed to measure pulses between zero and 100 volts with an accuracy of plus or minus 0.5 volts. The bias on V13 can be set and accurately indicated by the potentiometer R43. Pulses that exceed the bias will be amplified and trigger the multivibrator V15 and V16. The multivibrator output pulse is differentiated before being applied to the grid of V17. If a line terminated with 150 ohms is connected to J5 a pulse 3 volts high and 0.4 μsec duration will be obtained for every pulse that triggers the multivibrator.

The power supply is electronically regulated, the circuit being fairly standard. The recent 6AS7 tube is ideally suited for this application.

The amplifier must be used with a preamplifier. For proportional counters and fission chambers, this need be nothing more than a single cathode follower. Other applications require more gain, so a four stage preamplifier with a gain of 30 has been built. The circuit used (Figure 2) is similar to the Los Alamos Model 500 preamplifier. It consists of one feedback group similar to those in the main amplifier but using 6AK5 tubes, followed by a cathode follower output tube. A 7500 volts input condenser is used to permit the use of high voltages on the chamber. This condenser and all other insulators with high voltage across them should be cleaned and ceresin coated to prevent spurious counts.

Measurements have been made of the overall performance by applying a long pulse having a rapid rise and a slow decay to the preamplifier input. The pulse from the low impedance terminal at the output of the amplifier was examined by means of an oscilloscope containing an amplifier of 20 mc/sec bandwidth. The pulse rise time (10% to 90%) was observed to be 0.15 μsec for the wide band position; 0.7 μsec for the medium band position; and 4 μsec for the narrow band position.

Approximate signal to noise ratios were determined using the above signal generator. In the wide bandwidth position, a signal of 13 microvolts at the grid of the first preamplifier tube produced a signal at the output terminal equal to rms noise. On the medium bandwidth position, 5 microvolts of signal were required, while on the narrow bandwidth position, 3 microvolts were necessary. A useful signal must, of course, be many time rms noise.

Some of the construction details can be seen in Figure 3, Figure 4, and Figure 5. The preamplifier was constructed on a very shallow — 7-1/4 by 3-3/8 inches — chassis. A tight fitting cover slips on the bottom, being held in place and electrically connected to the chassis by anti-rattle clips. The amplifier and pulse height selector were built on individual subchassis and then bolted to a large 13 by 17 inches chassis containing the power supply. Adequate shielding is obtained by covers that slip on to each subchassis. The layout and wiring is such as to keep stray capacities and inductance to a minimum and yet keep all components where they are readily accessible for servicing. Ratings and quality of components were chosen with a view to reliable operation under constant duty. Complete construction details may be obtained from the authors by anyone desiring to duplicate this unit.

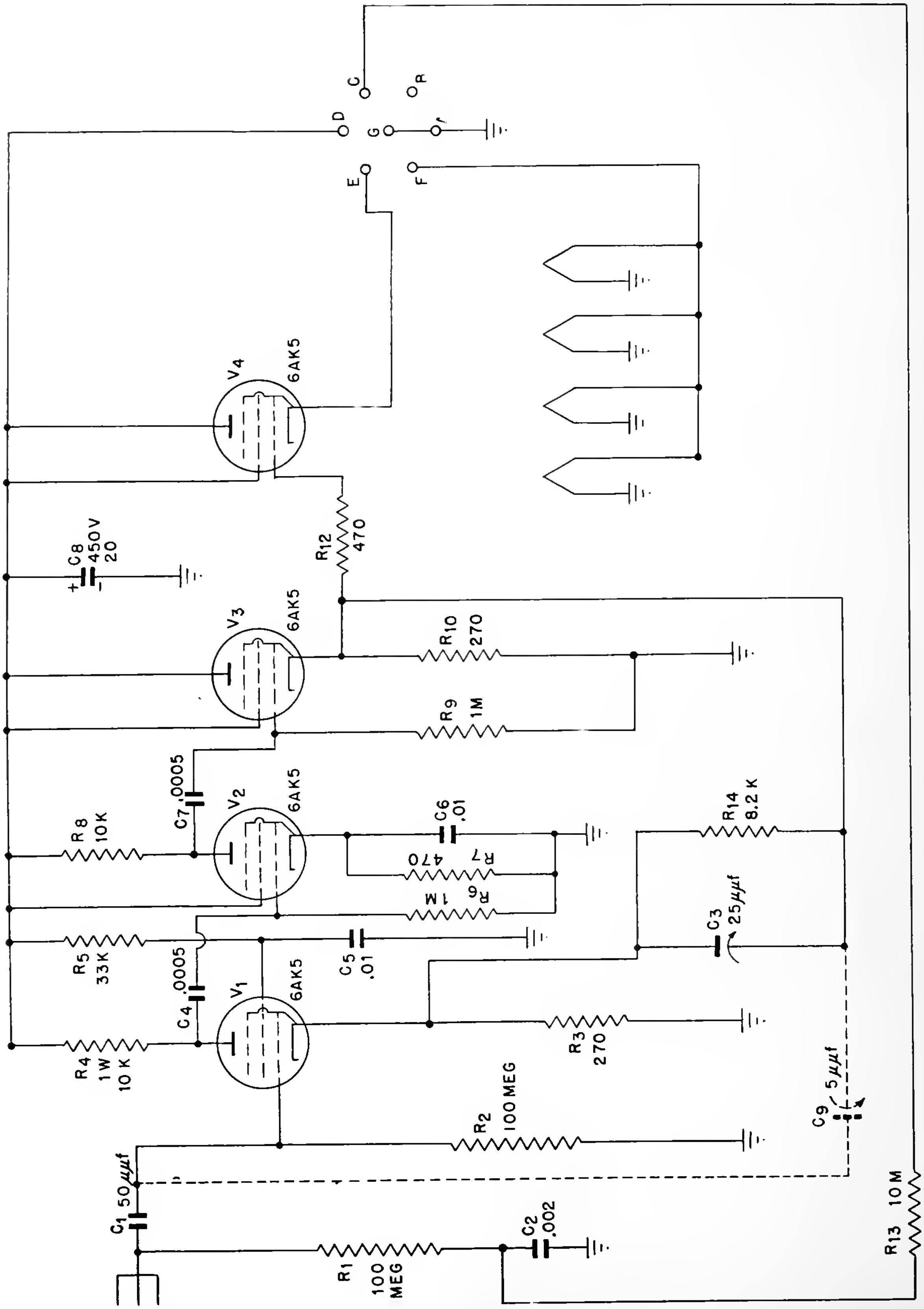

Figure 2. Preamplifier schematic

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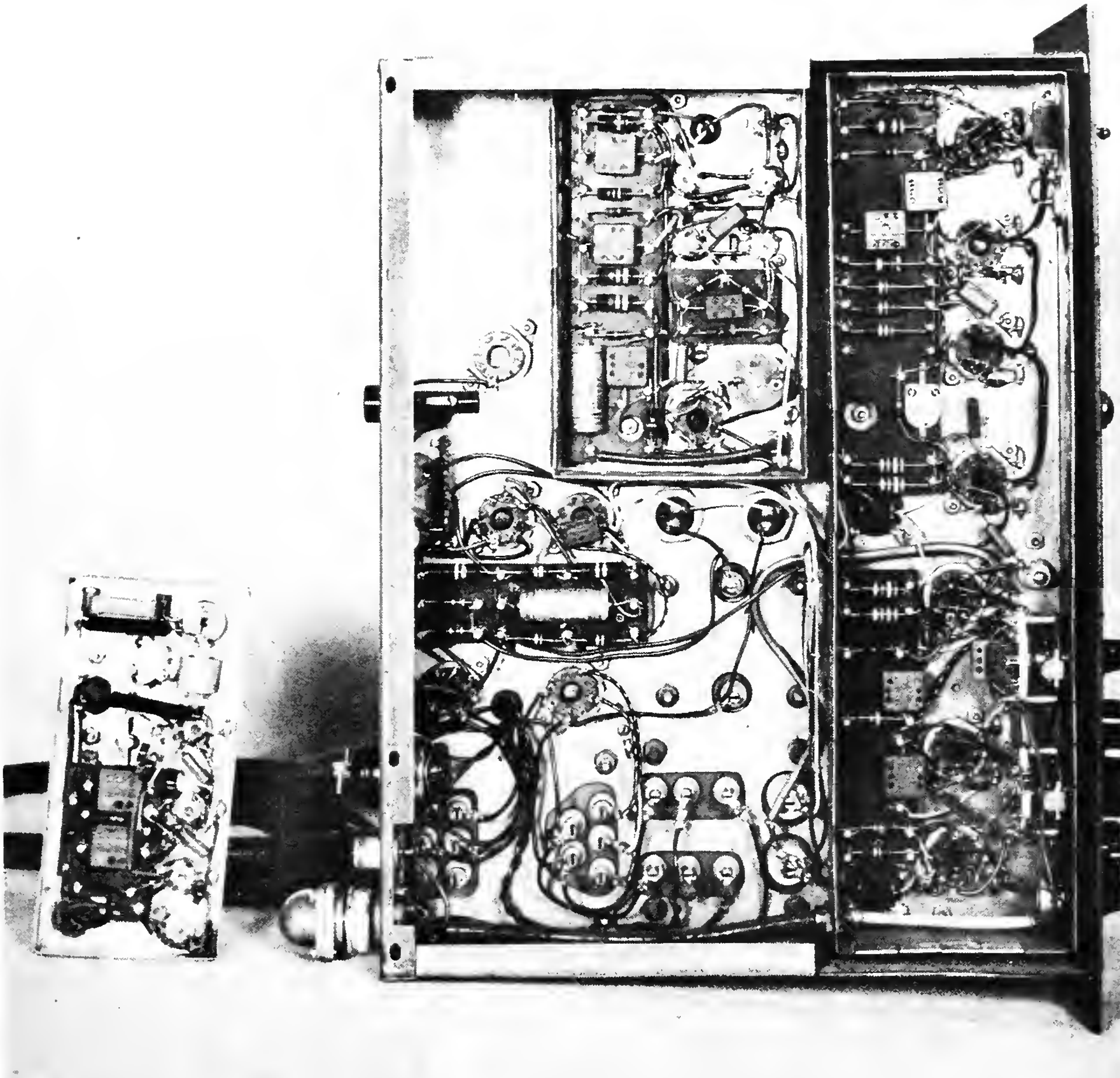

Figure 3. Bottom view of chassis.

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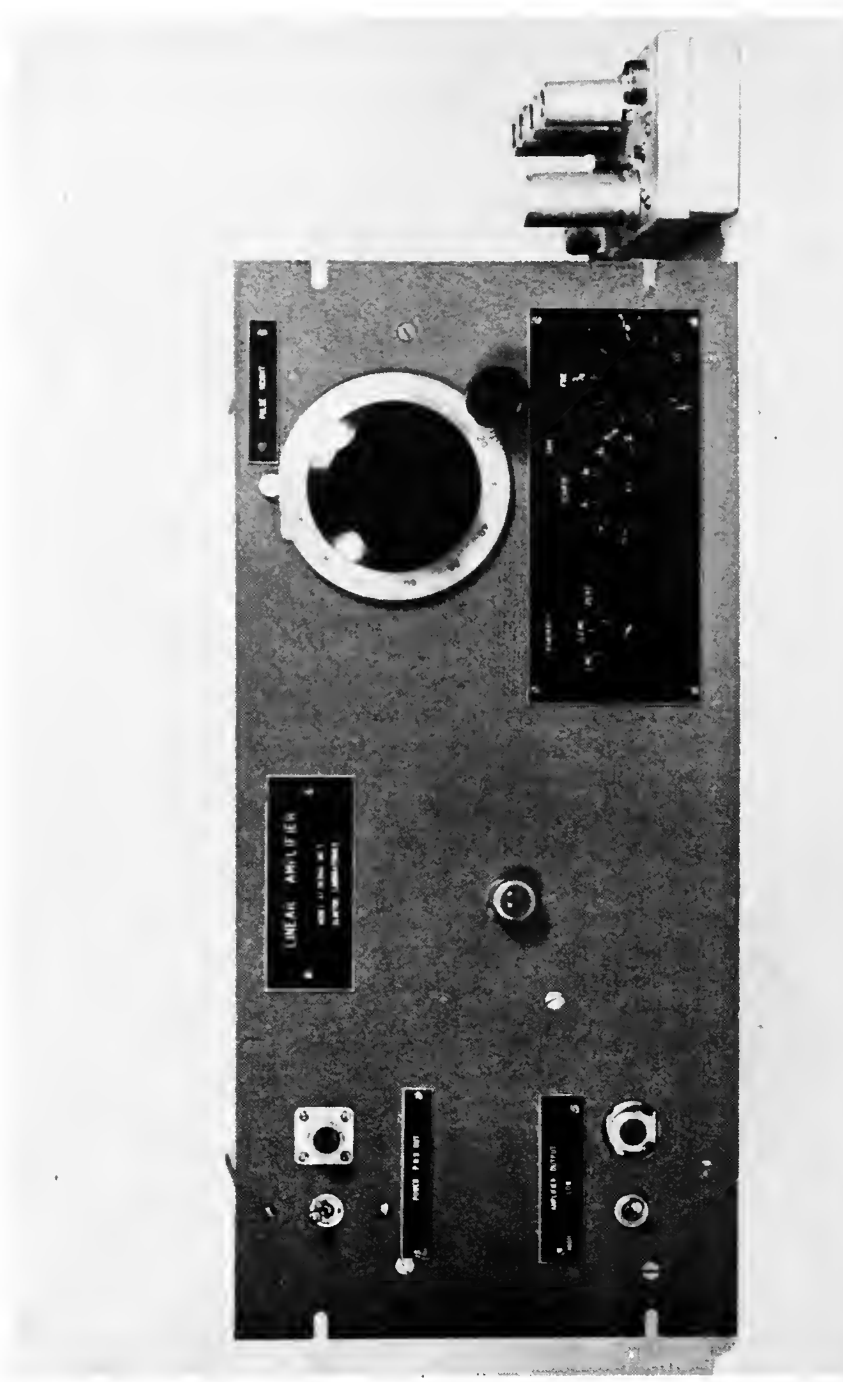

Figure 4. Front panel and preamplifier.

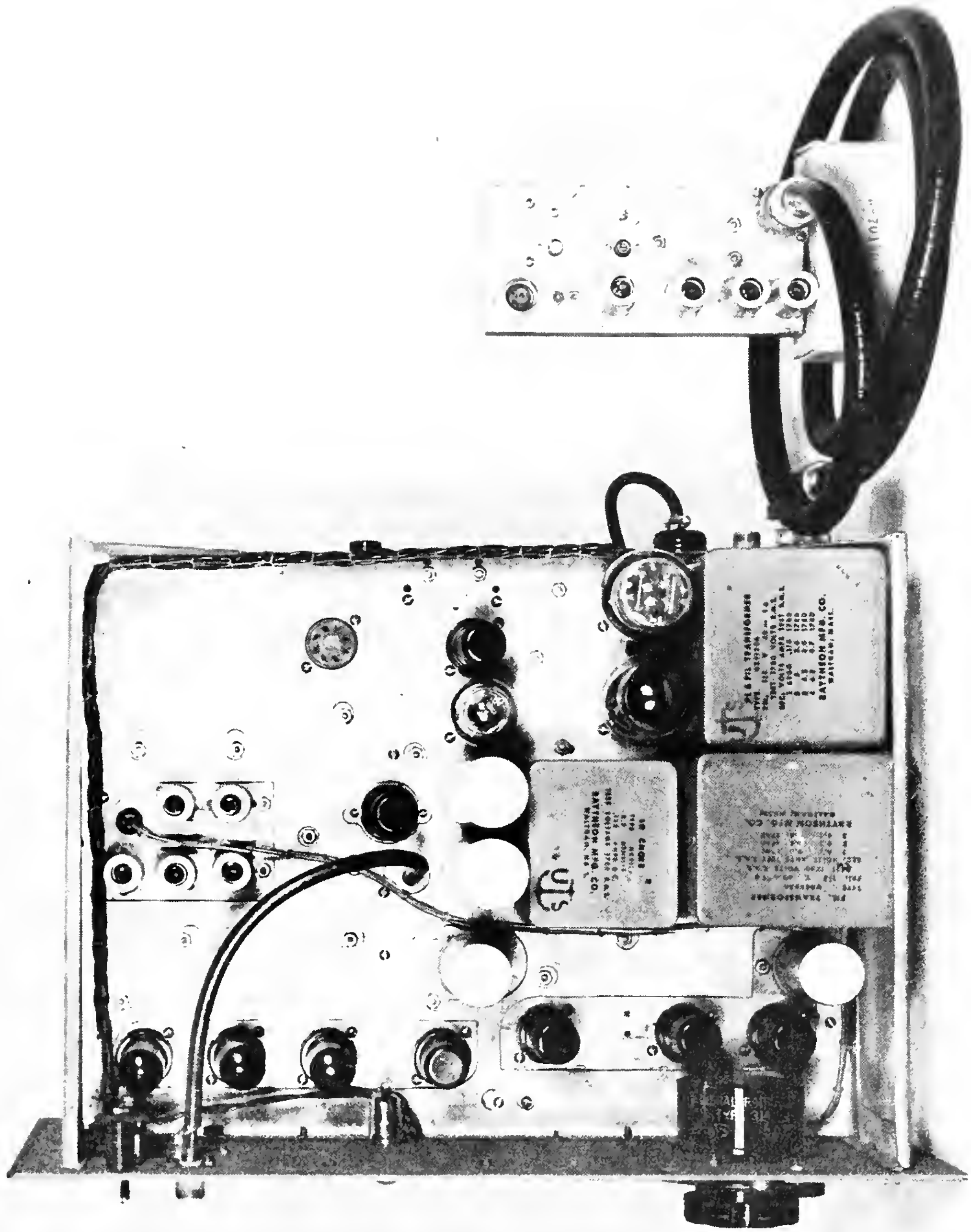

Figure 5. Top view of amplifier and preamplifier.